Commuting S.F. bay area
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Impact of BART on Transportation and Travel

Interim Service Findings

Interpretive Summary

July 1976

a report by the Metropolitan Transportation Commission

Metropolitan Transportation Commission

Hotel Claremont, Berkeley, California 94705

The Metropolitan Transportation Commission was established by California law in 1970. Its 19 members represent city and county governments, and federal, state and regional agencies that deal with transportation and urban development in the San Francisco Bay Area.

MTC's duties include: planning regional transportation; reviewing applications for federal funds for transportation improvements that have regional significance; and allocating state funds for mass-transportation projects.

As a part of its transportation-planning effort, MTC undertook the study of BART that is described in this report, which is distributed under the sponsorship of the U.S. Department of Transportation and the U.S. Department of Housing and Urban Development. The U.S. Government and MTC assume no liability for its content, or for the use made thereof.

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Photographs: Cover, page 9 and page 11 by Joel Markowitz of MTC. Pages 13 and 14 by the Bay Area Rapid Transit District.

BART: Expectations and Realities

In 1962, voters in three counties on San Francisco Bay approved the construction of BART, the Bay Area Rapid Transit system. They had been told that BART would cost less than $1 billion; that it would provide many commuters with an effective alternative to the automobile; that it thus would reduce automobile traffic on the Bay Bridge, which connects San Francisco to suburbs to the east; and that by 1975 it would carry more than 250,000 patrons a day on weekdays.

With construction nearly completed, BART's capital cost is approaching $1.6 billion. With all of its major links operating, BART is handling about 123,000 patrons a day. Although commuters compose a substantial part of its patronage, BART has had no important influence on the number of commuting trips made by automobile. And while BART's effect on Bay Bridge traffic is statistically detectable, it is negligible in any practical sense.

Why has BART not met its patronage goals? And why has it had so little effect on travel and transportation in the Bay Area?

One reason is evident: Early forecasts of BART's performance and impact rested on assumptions that weren't borne out. These included economic assumptions about inflation rates, operating costs and fares; and technical assumptions about the reliability of BART's equipment and the coordination of BART's service with automobile and bus travel.

But this needn't be the entire explanation for BART's mild impact. Planners and the public in the Bay Area apparently expected from BART more benefits than a rail rapid-transit system can reasonably be asked to provide. Their experience with BART calls into question the widespread belief that a fixed-route rapid-transit system can — by itself — affect significantly the volume and behavior of urban traffic.

These are some of the conclusions from a study of BART that is summarized in this report. The study was conducted by the Metropolitan Transportation Commission, and is called the Transportation System and Travel Behavior Project. It is a part of MTC's BART Impact Program, an inquiry into BART's influence on the people, the communities and the region that it serves.

Research Goals

The Transportation Project analyzes BART's effects on the travel habits of Bay Area residents and its intersection with other modes of transportation. This analysis has three major goals: to show how the planning and operation of a rail rapid-transit system affect its role in a regional transportation network; to provide information that can be used in improving transportation in BART's service area; and to derive principles that will help decision-makers plan transporation for other regions.

The Project was scheduled in two parts. During Phase I, completed in October 1975, researchers identified BART's initial effects on transportation and travel, and then collected and analyzed data describing these effects. Phase II, scheduled for completion in December 1977, will continue these evaluations, to weigh BART's benefits against its costs. It also will compare the effects of BART to the effects of the hypothetical tranportation system that probably would have evolved instead of BART.

The Phase I study was executed for MTC by Peat, Marwick, Mitchell & Co. (Burlingame, Calif.), and was supported by the U.S. Department of Transportation and the Department of Housing and Urban Development.

This report is a summary of Phase I findings, intended for public officials and other readers who have a general interest in rail rapid-transit systems.

Limitations of This Report

In applying the findings and analysis presented here to the planning and evaluation of other transportation systems, the reader must proceed with caution. There are three reasons for this:

First, the Phase I study examined temporary conditions. BART's operations were changing during the study period, and they will continue to change. Unquestionably, BART's effects will be altered as its operating schedule expands and its patronage grows.

Secondly, this study considered BART's effects on transportation only. Any overall evaluation of BART must also take into account its effects on land use, the regional economy, the natural environment and other aspects of life in the Bay Area. These are being studied elsewhere in MTC's BART Impact Program.

Thirdly, residential development in the Bay Area lies in long corridors that are defined by hills and the Bay. As a result, distances between BART's suburban stations range from 2 to 4 miles, and the average length of a trip on BART is 13 miles. BART differs greatly, then, from the transit networks that have been built, or might be built, to serve dense populations in strongly urbanized areas.


San Rafael
MARIN COUNTY
Richmond-San Rafael Bridge
Richmond
80
Berkeley
San Francisco-Oakland Bay Bridge
Golden Gate Bridge
San Francisco
Daly City
Oakland
Alameda
SAN FRANCISCO BAY
South San Francisco
280
San Mateo
San Mateo-Hayward Bridge
SAN MATEO COUNTY
Redwood City
Concord
24
Walnut Creek
Lafayette
Orinda
CONTRA COSTA COUNTY
San Leandro
Livermore
Hayward
ALAMEDA COUNTY
17
Fremont
SANTA CLARA COUNTY
San Jose
MUNI SERVICE AREA
A.C. TRANSIT SERVICE AREA
BART LINE WITH STATION
CONTRACT FEEDER BUS ROUTE
COUNTY BOUNDARY
San Mateo CITY OR TOWN
0 1 2 3 4 5 miles
0 1 2 3 4 5 6 7 8 kilometers

1 Transportation in the Bay Area

1.1 BART

BART lies within three Bay Area counties — San Francisco, Alameda and Contra Costa — whose combined population was shown as 2.4 million in the 1970 census. About 1.5 million people live within one mile of BART trackways.

BART's four suburban lines radiate from the dense urban cores of San Francisco and Oakland, and are named for their termini: Richmond, Concord, Fremont and Daly City. All of the lines pass through older, medium-density residential and industrial areas, and the Concord and Fremont lines extend into newer, lower-density suburbs.

1.2 Highways and Bus Systems

Some of BART's effects on travel in the Bay Area involve interactions with other modes of transportation. Examples: BART's impact on bus patronage, and its effect on bridge traffic.

The map on the opposite page shows the major elements in the Bay Area's transportation structure: BART, highways and local systems that operate buses, streetcars or both.

All of BART's lines run rather closely parallel to major highways. For assessing BART's impact on automobile traffic, the most important of these is Interstate Highway 80, which crosses the Bay Bridge.

Other important highways within BART's service area include Interstate 280, between San Francisco and some communities served by the Daly City line; California Highway 17 along BART's Richmond and Fremont lines; and California Highway 24, near the Concord line, which carries commuters between the Bay Bridge and some distant suburbs.

The most important bus systems in BART's area are the San Francisco Municipal Railway (MUNI), within the City of San Francisco; and the Alameda-Contra Costa Transit District (AC Transit), in the regions served by BART's Richmond and Fremont lines.

AC Transit provides local service in the East Bay and express buses to San Francisco from Oakland, Berkeley and several other communities.

Many MUNI and AC Transit lines act as feeders to BART, and can properly be regarded as appendages of the BART system. This is true especially of the feeder buses that AC Transit operates, under a contract with BART, in outlying suburbs that have no other public transportation to BART stations.

2 The BART System

2.1 Rights-of-Way

The length of the BART system is 71 miles. Of this, about 20 miles are underground: 13 miles in subway tunnel built by boring or by cut-and-cover work; 3 miles in a hard-rock tunnel on the Concord line; and 4 miles in the Transbay Tube beneath San Francisco Bay.

BART's 51 miles of above-ground trackways comprise 24 miles on elevated structures and 27 miles at grade or on earth embankments.

2.2 Stations

BART has 34 stations, of which 14 are below ground. Parking lots are provided at 23 of the stations. Their capacity ranges from 240 to 1,400 cars. Combined capacity of the 23 lots is about 19,000 cars.

BART's stations signify an important assumption by BART'S planners: that a pleasant environment for traveling would attract motorists out of their automobiles and into rapid-transit trains. The stations display a variety of architectural styles, and they conform to high standards of design, construction and finish.

2.3 BART Trains

BART cars are 70 feet long, and each can carry 72 seated passengers. BART's designers wanted all passengers to ride seated, and they provided neither grab rails nor overhead straps for standing passengers. In practice, however, peak-period trains on some BART lines carry more passengers standing than seated, and BART has begun installing grab rails in the cars.

The cars are unusually attractive and comfortable. Their interior features include air-conditioning, carpeting, tinted window glass, upholstered seats, and a public-address system for announcements of stations

and transfers. These appointments reflect again BART's hope that pleasing surroundings would attract patronage.

A BART train has two to ten cars. Although the cars can travel at 80 miles an hour, this maximum speed is attained only on the outlying sections of the Richmond, Concord and Fremont lines, and in the Transbay Tube. The average speed of all trains on all lines — computed to include both running time and stations stops — is about 40 miles an hour.

2.4 BART Fares

BART's fares range from $0.25 to $1.45; the chief determinant of the fare is the distance traveled. The fare schedule that was introduced when BART began operations in 1972 was retained until November 1975. In general, the new fares are higher than the original fares for long trips, and lower for short trips. The average fare now is 21% greater than the average of the original fares.

Fares from downtown San Francisco to some of the destinations shown on the map on page 4 are: $0.55 to Daly City; $0.75 to Oakland; $1.00 to Richmond; $1.20 to Lafayette; $1.35 to Concord; $1.10 to San Leandro; and $1.40 to Fremont.

2.5 Tickets and Ticket-Processing

Passengers can buy tickets in denominations from $0.25 to $20.00. The value left in a ticket after a trip can be applied to future trips.

Tickets are sold from machines and are processed by machines at both the origin and the destination of each trip. At the origin station, a machine marks the passenger's ticket with an origin code and returns it. At the destination, a second machine reads the origin code, devalues the ticket by the appropriate fare, and again returns the ticket to the passenger.

2.6 Train Operations

BART began running trains between Oakland and Fremont in September 1972. Operations began on the Richmond line in January 1973; on the Concord line in May 1973; and on the Daly City line in November 1973.

Service through the Transbay Tube was inaugurated in September 1974.

Initial service over all of these routes was confined to weekdays only, between 6:00 AM and 8:00 PM. BART began nighttime service in November 1975, and plans to begin weekend service by January 1977.

During the Phase I study, the daytime headway (time between successive trains) was 6 minutes on the Fremont and Daly City lines, and 12 minutes on the Concord and Richmond lines. Nighttime headway is 20 minutes.

2.7 Operating Problems

BART has had major problems with the performance and reliability of its equipment. These problems often have inhibited service, and they seem to have deterred some travelers from patronizing BART. Two important sources of trouble can be identified: BART cars and the automatic system that was installed to control them.

2.71 Problems with cars Failures of BART cars are unexpectedly frequent, and often involve the failure of motors or brakes. In March 1976, the percentage of BART cars available for service at a given time was usually about 50%. BART operations were designed with the assumption that availability would be at least 80%.

BART's policy is to recall to a repair yard any train that contains a car with a serious malfunction. Sometimes the train is returned to service after the defective car has been removed; sometimes a new train is dispatched to replace the one that was recalled.

During the first three months of 1976, an average of 14 trains a day were recalled.

BART's service schedule at that time required 30 operating trains during the daytime. Thus about half of the trains needed had to recalled. The Phase I study found that this noteworthy unreliability and the inconvenience that it causes to riders are discouraging patronage.

2.72 Problems with control BART employs a novel automatic train control system (ATC) that dispatches and routes trains, regulates their speeds and maintains minimum distances between them. The system includes a central computer at BART's headquarters in Oakland, 36 automatic control centers at stations and maintenance yards, control equipment on trains, and communication lines to carry data and commands between the control center and the outlying units.

ATC was intended to be a major advance in the control of vehicles by a computer. It exploits a novel control scheme, and is the largest system now in use on an operating rapid-transit network. But ATC has never fulfilled BART's expectations, and it has suffered some serious malfunctions.

Information about BART's problems with ATC, and about the methods that have been used in solving some of them, appear in the Phase I report listed in Section 8.

2.73 Major causes Three factors seem to have contributed strongly to BART's current operating problems.

- For several decades, the technology of rail transportation had been nearly static. BART's performance goals required the use of new technology that hadn't been tested under practical conditions. Hence, BART undertook two major tasks simultaneously: building a rapid-transit system, and developing the mechanisms that would make the system work.
- BART closed its test track too soon. As a result, many of the cars delivered to BART weren't tested rigorously before they were put into service.
- BART began passenger service before the ATC system could be tested thoroughly. As soon as BART started to carry passengers, testing and modification of ATC became more difficult and more costly.

2.74 Pending lawsuits BART has alleged that problems with its cars and with ATC have arisen from inadequate design, poor quality-control during manufacture and deficient documentation of the systems involved. The last of these, BART says, has hindered corrective efforts. These allegations appear in lawsuits that BART has filed against some of its contractors and suppliers.

The major defendants haven't yet replied to these allegations.

3 Findings: BART Patronage and Patrons

3.1 Predicted and Actual Patronage

BART's patronage hasn't reached predicted levels, and the difference is substantial.

The earliest forecast of patronage appeared in 1962 in a report by several of BART's contractors and consultants.* They predicted weekday patronage of 259,000 by 1975. Lower figures appeared in later reports, the last of which was issued in December 1971 by BART's Office of Research. It forecasts 200,000 trips a day (excluding trips by primary- and secondary-school pupils) when BART attains and stabilizes its full operating schedule.

In September 1974, when BART introduced Transbay service, average daily patronage reached 120,000. It has changed little since then. The average for the first three months of 1976 was 123,000. Thus, BART's patronage has been nearly static since its last major section, the Transbay Tube, was opened.

Similar findings emerge when BART's major sections are considered separately. Example: By June 1973, all three of BART's East Bay lines — Fremont, Richmond and Concord — were in operation. Their average combined daily patronage in that month was 37,000. In March 1976 it was 41,000.

*Parsons-Brinkerhoff-Tudor-Bechtel, Smith Barney & Co., Stone & Youngberg, and Van Beuren Stanbery. 1962. *The Composite Report, Bay Area Rapid Transit.*

3.2 BART's Share of Travel

BART's patronage appears small when it is expressed as a percentage of all trips made by vehicle in the BART service area. In May 1975 BART was handling:

2% of the total number of trips made during an entire week (weekdays and weekend).

3% of weekday trips made between 6:00 AM and 8:00 PM.

8% of weekday trips between home and job, between 6:00 AM and 8:00 PM.

An even clearer statement of BART's small significance is this: Repondents to the May 1975 survey reported that only 9% of their trips during an entire week were made *or could be made* on BART.

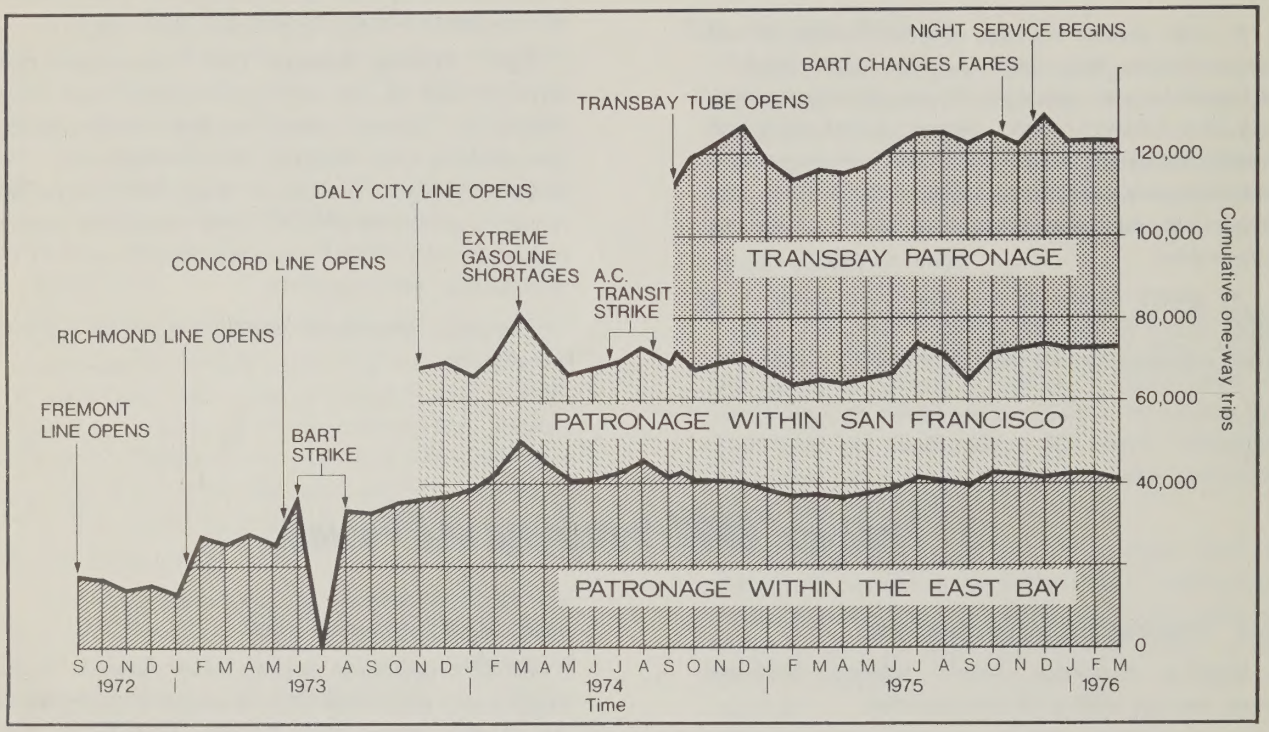
If Transbay travel alone is considered, BART appears to be more important. A survey in October 1974 disclosed that BART was carrying 21% of weekday Transbay trips between home and job, between 6:00 AM and 8:00 PM.

3.3 Factors Affecting Patronage

Two reasons why BART hasn't attracted more patrons are evident: its limited operating schedule and the unreliability of its service. The Phase I study identified some other factors affecting BART patronage by examining the benefits and the problems that BART presents to its riders.

3.31 Effects on travel time and cost The October 1974 survey of Transbay travelers sought

Patronage on each of BART's major sections has been static. Small losses due to fare increases were offset by the initiation of night service.



information about travel time and cost from four groups of respondents: BART riders who formerly traveled by bus; travelers who continued to use buses; BART patrons who formerly used automobiles; and travelers who continued to use automobiles.

The results showed that none of these groups thought that BART could save them significant amounts of time. BART riders who formerly used buses thought that the two modes were closely comparable, in both travel time and cost. The other groups thought that they were losing time, or would lose time, by using BART.

The automobile-riders and the former automobile-riders had similar ideas about the costs of travel by BART and by automobile: both groups thought that BART could save them $1.50 to $3.00 on each trip. But the automobile-riders thought that they would lose an average of 46 minutes by making their trips on BART, while the former automobile-riders believed that they were losing only 27 minutes by riding BART.

Commuters' estimates of the cost of automobile travel need not be accurate or consistent, but they are important for understanding how travelers compare automobiles with BART. Answers to the 1974 survey indicate that cost comparisons are very important in a traveler's choice between BART and automobile, but suspected losses of time are crucial.

3.32 Capacity Problems To travelers who do decide to use BART, the system presents two major problems: inadequate parking capacity at suburban stations, and insufficient seating on trains.

Parking The October 1974 survey showed that about 60% of all Transbay BART trips were begun or ended by automobile. For trips between a home in the East Bay and a job in San Francisco the corresponding figure was 78%.

The use of automobiles for travel to and from BART stations is vital in low-density suburbs, which cannot support the extensive local bus systems that are found in strongly urbanized areas.

When they chose a system whose patrons would have to use automobiles extensively, BART's designers recognized that they would have to provide abundant parking capacity at suburban stations. Plans proposed in 1962, for example, called for a total of 36,000 parking spaces in BART parking lots. That number eventually was cut in half, to reduce BART's construction costs. Under present circumstances — i.e., sparse bus service to BART's suburban stations — BART's parking capacity is obviously inadequate.

Since the Transbay Tube opened, the parking lots at outlying stations on the Concord and Fremont lines have been filled each morning by 9:00 AM, and

usually much earlier than that. It seems clear that parking-lot capacity on these lines limits BART patronage, by restricting the number of patrons who can park and ride.

Seating In October 1974, load factors between 1.5 and 2.0 were common on peak-period trains from Concord to San Francisco. Load factors approaching 3.0 were seen on some trains.

(A load factor of 1.0 means that all seats are occupied, but no passengers are standing. At 2.0 there are as many standing passengers as seated. At 3.0 there are twice as many standing as seated.)

Certainly, most urban rapid-transit systems exhibit load factors greater than 1.0 during peak travel hours. But BART's high load factors have special significance, for two reasons. First, they weren't anticipated; BART's planners declared that all patrons would find seats, at all times of day. Secondly, the typical Transbay rider is a commuter whose trip might take 30 or 40 minutes; few travelers enjoy standing for so long a time.

Indeed, field observations suggest that the scarcity of seats on BART trains is retarding patronage. Example: BART consistently captures a larger share of Transbay travel from the outermost communities on the Fremont line than it does from the outlying communities on the Concord line. This seems attributable to the fact that there are more seats available on the Fremont-line trains, since there is less demand for Transbay travel on that line.

3.4 Perceptions of BART

This analysis of factors limiting BART patronage is reinforced by the results of a 1974 survey of Transbay travelers' impressions of BART. Their attitudes were influenced chiefly by the frequency and reliability of service.

In general, respondents were satisfied with BART's comfort, safety and security. And they were dissatisfied with the dependability of BART trains, the door-to-door time required for trips on BART, the availability of seats on trains and the availability of parking spaces at stations.

3.5 BART's Patrons

Data on the entire BART system showed that BART's riders are generally representative of the Bay Area population, with one exception: Although BART has spent considerable sums to provide special facilities for the disabled, its patrons include fewer of these persons than are present in the general population. While the disabled probably travel less than others do, their use of BART seems to be limited further by difficulty in traveling to BART stations; by problems with using BART facilities; and by a lack of information about BART's special provisions for disabled riders.

Local data from particular BART stations showed two special cases. At some urban stations, certain

A westbound train to San Francisco and Daly City arrives at BART's Orinda station on a weekday morning, as cars stream westward on Highway 24.

minority goups were represented less among BART's patrons than in the local population. And Transbay riders had somewhat higher incomes than do Bay Area residents as a whole.

The low representation of some minority groups seems attributable to the concentration of these groups near urban centers, where most of their travel consists of short trips. BART's fares often are higher than bus fares for such trips, and BART's travel-time advantage – if any– is least.

The unusually high incomes of Transbay riders reflect the fact that may of them are commuters who work in downtown San Francisco. Necessarily, commuters have jobs. And white-collar jobs in San Francisco usually pay above-average salaries.

Research in 1974 showed that 25% of Transbay riders represented families that earned at least $25,000 a year. Among BART's patrons within San Francisco, the corresponding figure was 10%. Among riders within the East Bay it was 13%.

4 Findings: Effects on Other Modes of Travel

4.1 Effects on Bus Patronage

BART has captured more of its patrons from buses than from cars. This is especially noticeable when sources of Transbay patronage are analyzed.

4.11 Effects on Transbay patronage The October 1974 survey of Transbay BART travelers showed that 54% of their trips had been made previously by bus and 35% by automobile. The remaining 11% were "new" trips that the respondents hadn't made before. The survey didn't indicate how may of these new trips, if any, could reasonably be attributed to the availability of BART.

The diversion of trips from bus to BART was most noticeable among commuters. About 63% of BART trips between home and job had been made formerly by bus. Only 34% of the trips made for other purposes had been captured from buses.

Greyhound commuter buses from central Contra Costa County to San Francisco showed an especially sharp loss of patronage when BART started Transbay service. In June 1974, commuters used Greyhound for more than 12,000 trips a day. By June 1975, patronage had fallen to less than 3,000 trips a day.

4.12 Effects on local patronage The assessment of BART's impact on bus travel within San Francisco and within the East Bay is complicated by the fact that bus lines interact with BART in two ways. In some situations, they compete with BART. In others, they complement BART – and thus gain riders – by moving passengers to and from BART stations.

Research during Phase I detected no significant impact of BART on MUNI's overall patronage, although it showed that three MUNI lines parallel to BART's Daly City line had lost 25% to 50% of their riders to BART.

Similar findings were made in the East Bay. Although BART seems to have captured substantial numbers of riders from particular AC Transit lines, this diversion has been offset by patronage increases due to other influences.

4.13 Effects on bus operations Under a plan devised by the California Public Utilities Commission and Greyhound Bus Lines, Greyhound has curtailed severely its service on routes that run parallel to BART, linking central Contra Costa County to Oakland and San Francisco. Greyhound had wanted for some years to reduce its schedule of commuter express buses, but the P.U.C. had required Greyhound to operate a substantial number of commuter buses until BART could provide an alternative.

In general, however, BART has produced only small effects on the nature and frequency of bus service in the Bay Area. AC Transit has reduced the number of Transbay express buses that it operates during peak commuting hours, but no routes have been abandoned. MUNI, AC Transit and several smaller companies have expanded service on some local lines, to carry BART patrons between their homes and BART stations. And, as was noted in Part 1.2, AC Transit is operating feeder buses for BART in some suburbs that had no local bus service.

4.2 Impact on Automobile Traffic

BART has had little effect on the volume or behavior of automobile traffic. A major source for this finding was an analysis of actual and predicted traffic volume between January 1972 and May 1975 on the four major bridges that span San Francisco Bay (map, page 4). Of these four, the Bay Bridge alone was affected by BART. The three others provided baselines for the analysis of BART's impact.

4.21 Effects on Bay Bridge traffic The prediction that BART would reduce congestion dramatically on the Bay Bridge hasn't been fulfilled.

On weekdays during the summer of 1974, before BART introduced Transbay service, the Bay Bridge handled about 94,000 vehicles a day in each direction. These represented about 129,000 trips – 98,000 travelers in automobiles and 31,000 in buses.

Shortly after BART trains began running through the Transbay Tube, weekday traffic on the Bridge declined by about 11,000 trips (or about 8.5%). Soon thereafter, however, trips increased by 7,000. By May 1975, the net reduction had shrunk to 4,000 (about 3.1%).

These 7,000 "new" trips are difficult to explain. They might be trips that were captured from other routes when traffic on the bridge was reduced temporarily by the opening of BART. Or they might represent induced travel – trips that previously had been discouraged by congestion on the bridge, but which became attractive as soon as BART began to relieve that congestion.

Induced travel is a common phenomenon. Wherever an automobile route is used heavily, there exists a reservoir of trips that people don't make because the route can't accommodate them. If a second route is provided, both routes will draw traffic from this reservoir. Thus the net loss of traffic from the old route will be considerably less than the gain of traffic by the new route.

BART's impact on Bay Bridge traffic might have been diluted by some changes in the operation of the bridge itself. These changes, introduced between December 1971 and May 1975, included the establishment of lanes reserved for buses, the elimination of the bridge toll during daytime for automobiles carrying three persons or more, and the installation of a signal system for optimizing the flow of traffic.

4.22 Effects on travel time Because of the obvious importance of the Bay Bridge, changes in travel time on the bridge were examined carefully. After the opening of BART's Transbay service, the average speed of vehicles crossing the bridge during the morning peak period increased from 16 to 18 miles an hour.

This change – a reduction of about 2 or 3 minutes in the time required to cross the bridge – might be due partly to BART. Even if it is attributable wholly to BART, it represents a very small change in the typical commuter's driving time.

4.23 Effects on peak-traffic period Since BART began Transbay operations, the morning peak-traffic period has shortened slightly, and its center has shifted from about 7:30 AM to 7:45 AM.

A similar shift was observed on California Highway 24, an important artery for bridge-bound traffic. Again, there was no significant change in average speed, but the peak of congestion was displaced by about 15 minutes. These shifts suggest that the small reduction in traffic on the Bay Bridge has enabled some travelers to begin their journeys somewhat later. But the shifts cannot be attributed definitely to BART. They might reflect seasonal variations in traffic behavior, or the impact of the 1974 gasoline shortage on travel habits.

Evening commuters leaving the Orinda station. Suburban patrons depend heavily on cars, and the parking capacity at most stations is inadequate.

5 Findings: Costs, Deficit and Energy-Consumption

5.1 Capital Cost

The money used in building BART has been raised chiefly through bonds. Funds for servicing these bonds come from a property tax and a sales tax collected in the three BART counties, and to a much smaller extent from bridge tolls.

The first BART planning report, issued in 1962, said that BART would cost $994 million to build and equip.

Construction is nearly finished now. The BART District's current estimate of the system's ultimate capital cost is $1.608 billion – about 62% more than the 1962 prediction.

The difference between these figures reflects price inflation, construction delays whose effects were amplified by inflation, and changes in the system's original scope and design. The importance of these three forces can be shown by subtracting their effects from BART's latest cost estimate. The remainder is only 6% greater than the 1962 estimate.

The major fault of the 1962 prediction was that it assumed an inflation rate of 3% per annum. Actual inflation rates varied between 3% and 5% during the years 1962 and 1966, and between 8% and 14% during the years 1967 to 1973.

The greatest proportional increases in BART's cost over the 1962 forecast have been associated with the purchase of the BART cars, with fees for engineering and management services, and with pre-operational testing (operating empty trains over each major section of the system before it is opened for passenger service).

The average cost of BART's 450 cars was $357,800 instead of the $157,800 foreseen in 1962. Engineering and management fees will total $145 million, according to present estimates, instead of $74 million. And preoperational testing will cost $77 million, instead of $7 million.

5.2 Operating Costs

The Phase I study produced no firm measurements of BART'S operating costs, for two reasons: "Operating" costs during the study period actually included substantial expenses for testing, modification and start-up of new equipment. And any cost measurements developed now will become obsolete as soon as BART expands its service schedule. The Phase I report listed in Section 8 describes recent changes in BART's non-capital costs.

5.3 Deficit

BART's present deficit from passenger service – the difference between fare revenue and all non-capital expenses – is $1.31 per passenger. During the first six months of 1975, BART spent an average of $1.90 and collected $0.59 for each passenger that it carried.

The 1962 planning report predicted an operating profit of $0.14 per passenger. The immediate reasons why BART hasn't even approached such a profit are clear: BART's fares have increased much more slowly than its costs (especially its labor costs). And the 1962 report's highly optimistic patronage predictions forced corresponding errors into its cost and revenue predictions.

A fundamental error in the 1962 forecast was the assumption that a contemporary public transit system could be supported by fare revenues alone. All recent experience in the United States shows that the survival of such systems requires a direct public subsidy, or indirect support through changes in the management and prices of alternative modes of travel.

BART's present ratio of fare revenues to non-capital expenses is similar to the corresponding ratios for other transit systems in the Bay Area.*

The California Legislature now is studying several proposals for long-term financing of the operating costs of all public transit services in the Bay Area.

5.4 Energy-Consumption

When BART attains and stabilizes its full schedule of service, it will use less than half as much energy as the typical automobile requires to move one passenger one mile. Under some conditions – notably during peak commuting hours, when public vehicles are fully loaded and private cars are not – BART's advantage will become substantially greater.

Energy-consumption comparisons between buses and rail systems are infuluenced strongly by the load factors assumed in the analysis. In a few situations, BART might be as efficient as buses would be. But under typical circumstances, BART won't be as efficient as a bus system of comparable capacity.

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*Legislative Analyst, State of California. 1975. *Financing Public Transportation in the San Francisco Bay Area.*

6 Review

This section restates the major Phase I findings about BART's role in Bay Area transportation, and about the factors that have shaped that role. These factors should receive close attention from decision-makers who are considering rapid-transit systems for other metropolitan areas.

Patronage and Patrons

- BART's current patronage is about 123,000 trips a day on weekdays. This is substantially below the patronage levels suggested in early forecasts. It isn't known whether those predicted levels ever will be attained.

- On each of BART's major sections, patronage has been static since the section opened. The system's total patronage hasn't changed since the Transbay Tube opened in September 1974.

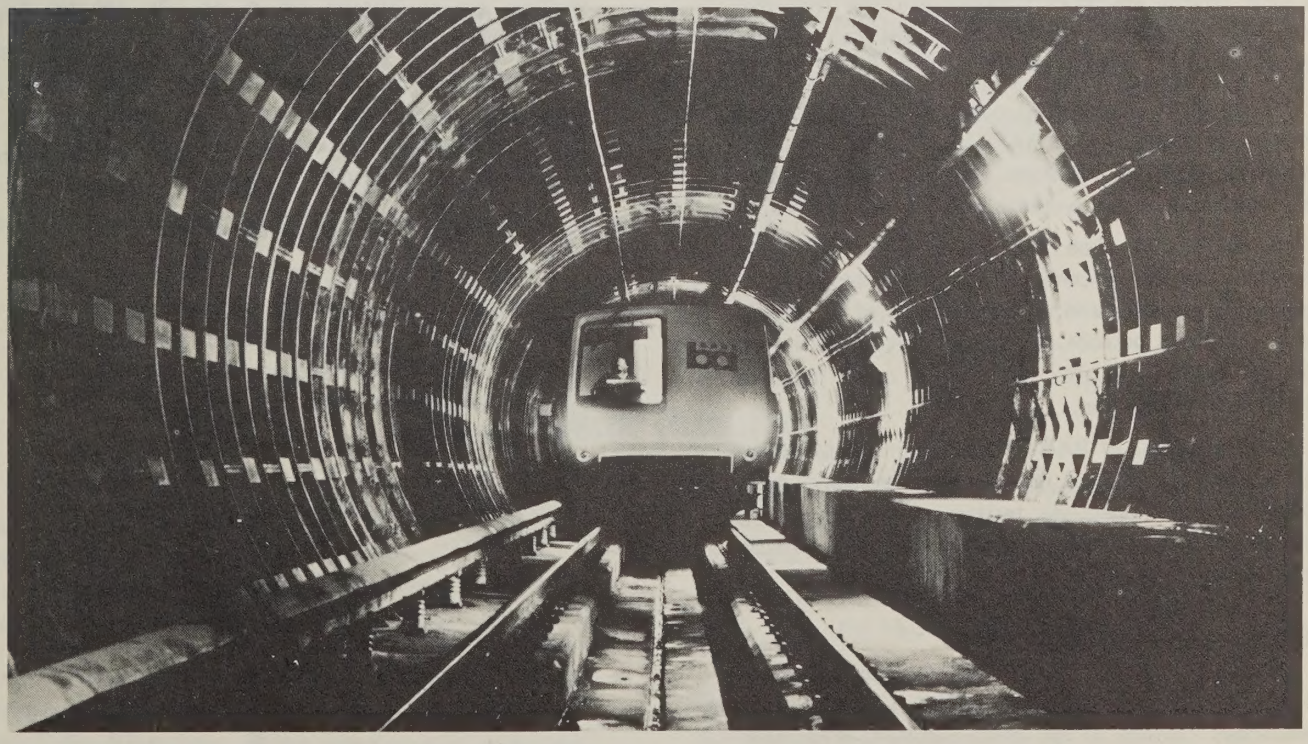
- In most respects, BART's patrons reflect closely the composition of the general population in BART's service area. Transbay patrons have somewhat higher incomes than the population at large, because this patronage segment is dominated by commuters.

- BART has captured about 54% of its Transbay patronage from buses and about 35% from automobiles. BART's diversion of trips from automobiles is comparable to (or better than) than recent performance of systems in other metropolitan areas.

- There are few situations in which BART offers clear time and cost advantages over alternative modes of travel. For most trips, BART is more costly than a bus and slower than an automobile. BART can compete most effectively for the commuter who makes long trips from an origin that isn't served by another public transit system; or for the driver who must park in an expensive garage at his destination.

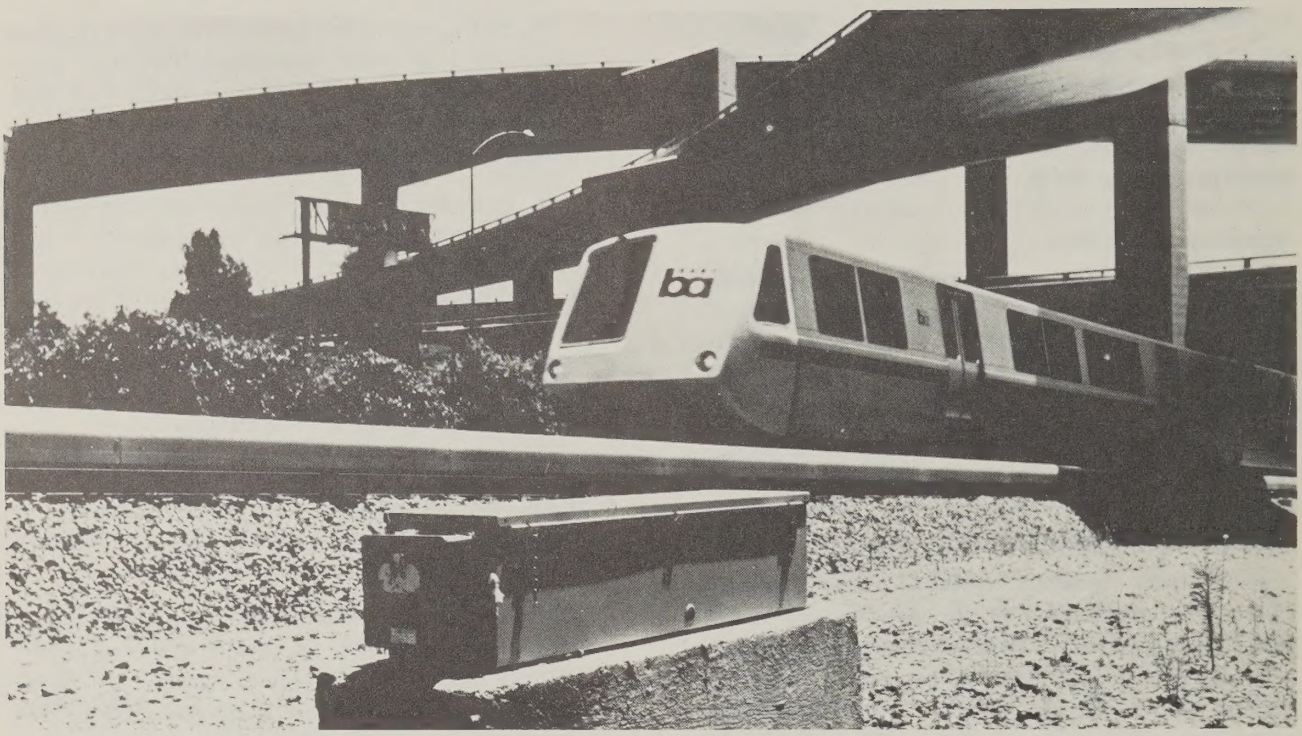
- Transbay commuters generally believe that a BART ride costs less than an automobile trip. But to many of them, this cost advantage is less important than the time advantage offered by a private car.

- BART's usefulness to East Bay commuters is limited by the number of parking spaces at BART parking lots and the seating capacity of BART trains. The parking problem is aggravated by the lack of adequate feeder-bus service in outlying suburbs.



A BART train speeding through the Transbay Tube. There has been no significant change in BART's total patronage since this Tube opened in 1974.

This trackside signal unit is a part of BART's automatic train control system. Major problems with the system have reduced BART's reliability.



• BART's planners recognized that the system would require abundant parking facilities. Nonetheless, the number of parking spaces proposed in early plans for BART was cut in half.

• Comfort, decor and other qualitative factors that were emphasized in BART's design have won the approval of BART's patrons. In general, patrons also are satisfied with the system's safety and security.

• BART has had serious problems with the reliability of its equipment. These are reflected in its operating statistics and in the attitudes of its patrons and potential patrons. The poor dependability of BART service probably is deterring some travelers from using the system.

• The causes of BART's equipment problems include: the use of new technology that hadn't been tried before; inadequate testing of delivered cars; initiation of passenger service before the automatic train control system could be tested thoroughly.

Effects on Other Modes of Travel

• BART carries 21% of the commuters who travel between the East Bay and San Francisco on weekdays. Outside of this major commuting corridor, BART's importance is small.

• Probably because BART hasn't attained predicted levels of patronage, it hasn't produced predicted reductions in automobile traffic. It has worked no significant effect on the volume or behavior of traffic on the Bay Bridge.

• Although BART captured most of its patrons from buses, total bus patronage in the Bay Area hasn't declined. Bus lines have gained at least enough new riders to offset BART's inroads.

Costs, Deficit and Energy-Consumption

• The current forecast of BART's final capital cost is 62% higher than the estimate published in 1962. Almost all of this increase is attributable to inflation, construction delays, and changes in the system's scope and design.

• BART is operating at a deficit. Its ratio of revenues to non-capital costs is comparable to the ratios exhibited by other public transit systems in the Bay Area.

• There is no reason to believe that BART can be supported by fare revenues. All recent American experience with public transportation contradicts that 1962 prediction.

• Estimates of energy-consumption per passenger-mile show that BART will be using energy much more efficiently than a car can. In most circumstances, however, BART cannot be as efficient as a bus system.

7 Analysis

Final judgments about BART can't yet be made, since the system is still evolving. But some important lessons already have been suggested.

Earlier sections of this report have shown that the expectations of the early 1960s haven't been met, and that BART has had surprisingly little effect on travel behavior and on the performance of the Bay Area's transportation system.

One reason for this already has been emphasized. Early forecasts of BART's patronage and impact rested on assumptions that weren't borne out. These included economic assumptions about inflation rates, operating costs and BART's ability to raise fares as its costs rose; and technical assumptions about the reliability of BART's equipment and the close coordination of BART's service with automobile and bus transportation.

But this needn't be the only explanation — or even the most important explanation — for BART's mild impact. Many planners, public officials and residents of the Bay Area apparently expected from BART more travel benefits than a rail transit system can reasonably be asked to provide. The fundamental lesson of BART seems to be this: Planners must reconsider the conventional belief that a fixed-route rapid-transit system can — by itself — relieve urban traffic congestion and decrease the use of energy by an urban transportation system.

BART has attracted only a small fraction of the trips made by residents of the three BART counties. Even in the Transbay corridor, where BART carries significant numbers of travelers during weekday commuting hours, it has captured only those trips that begin and end near BART stations.

Such trips compose only a small part of travel in the Bay Area, for an obvious reason. During the past 30 years, most of that region's growth has occurred in sprawling, low-density suburbs whose residents would travel by highway to commercial and industrial centers. No fixed-route system alone could have affected greatly the habits of commuters whose suburbs were designed and located for automobile-riders. To say this another way: 71 miles of BART trackways couldn't supplant the 6,000 miles of highways and streets in BART's service area.

If BART eventually attains the patronage that its managers now are predicting (about 200,000 riders a day on weekdays), will its effects on traffic congestion become more pronounced than they are now? Not necessarily. If there are no changes in travel habits — routes used, scheduling of trips, and diversion of trips from automobiles to BART — the traffic load on the Bay Bridge during peak commuting periods will be only 15% less than it was in 1974, when BART opened its Transbay link.

Regarding energy-consumption: BART now carries about 2% of the total trips made weekly in its service area. Even if that percentage tripled, BART's effects on gasoline consumption would be negligible. A transportation system can relieve energy problems only if it is part of a unified regional attack — a plan that embraces all modes of travel, and uses technical, political and fiscal tactics to promote the most efficient ones.

8 Technical Literature

These MTC publications provide further information about Phase I of the BART Impact Program's Transportation System and Travel Behavior Project. All of them will be available from the National Technical Information Service (Springfield, Va.).

Transportation and Travel Impacts of BART: Interim Service Findings. 1976.
Report No. FR 6-3-75. 192 pp.

Transportation System and Travel Behavior Project Research Plan. 1975.
Report No. PD 14-3-75. 114 pp.

Analysis of BART's Energy Consumption for Interim System Operations. 1975.
Report No. WP 14-3-75. 18 pp.

Immediate Travel Impacts of Transbay BART. 1975.
Report No. TM 15-3-75. 110 pp.

Exploratory Network Analyses of BART's Impacts Upon Accessibility. 1975.
Report No. WP 15-3-75. 46 pp.

Assessment of the Impacts of the AC Transit Strike Upon BART. 1975.
Report No. TM 11-3-75. 53 pp.